Multi-wavelength observations of prominences (ALMA, IRIS and GB spectrographs)

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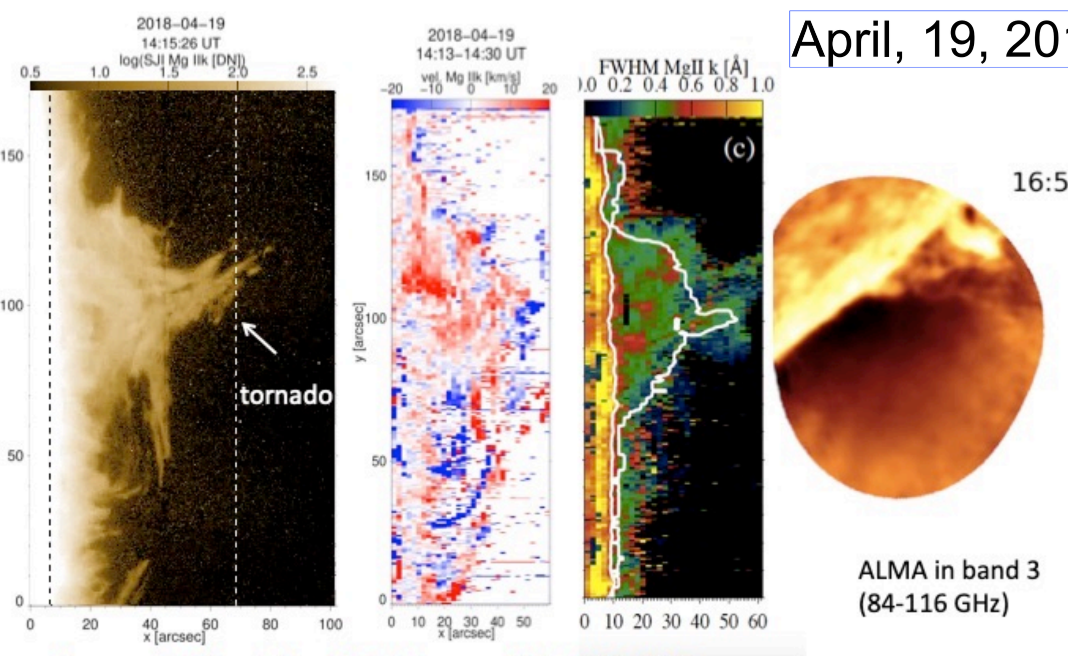
Overview:We present prominence observations obtained with spectrographs (ground-based including ALMA) and from Space (IRIS). Mg II spectra and Hα profiles are compared to synthesised profiles obtained with NLTE radiative transfer codes (Levens & Labrosse2019). New approaches are developed to fit the full profiles of Mg II lines with 1000/23940 models where the prominence-corona transition zone (PCTR) is taking into account. PCTR is important for prominence threads in formation while ALMA reveals the existence of very cool plasma (6000K).

Tornado

IRIS Observations and Dopplershifts and ALMA

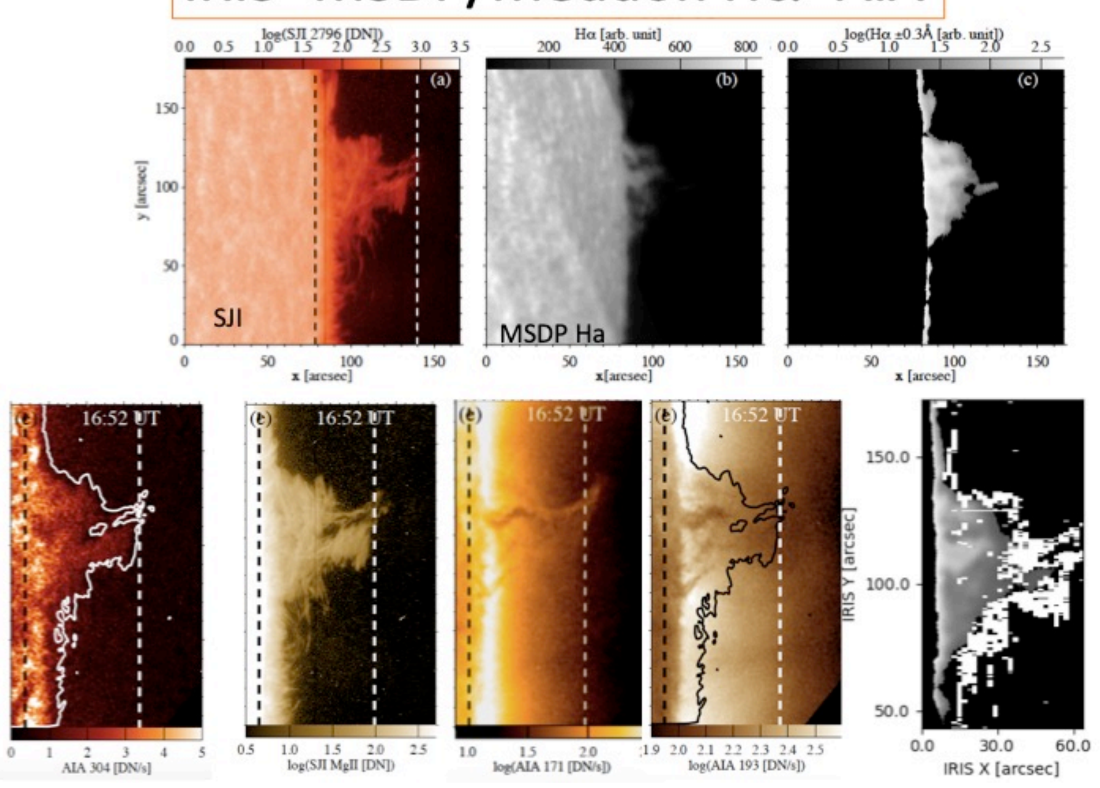
April, 19, 2018



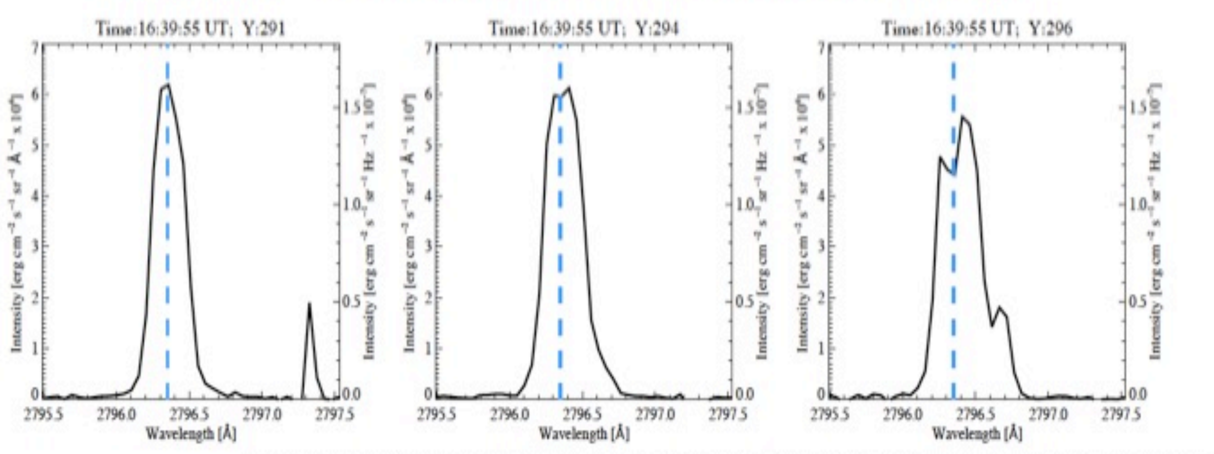
Barczynski, Schmieder, Peat, Labrosse, Mein 2021 A&A

Labrosse et al 2022

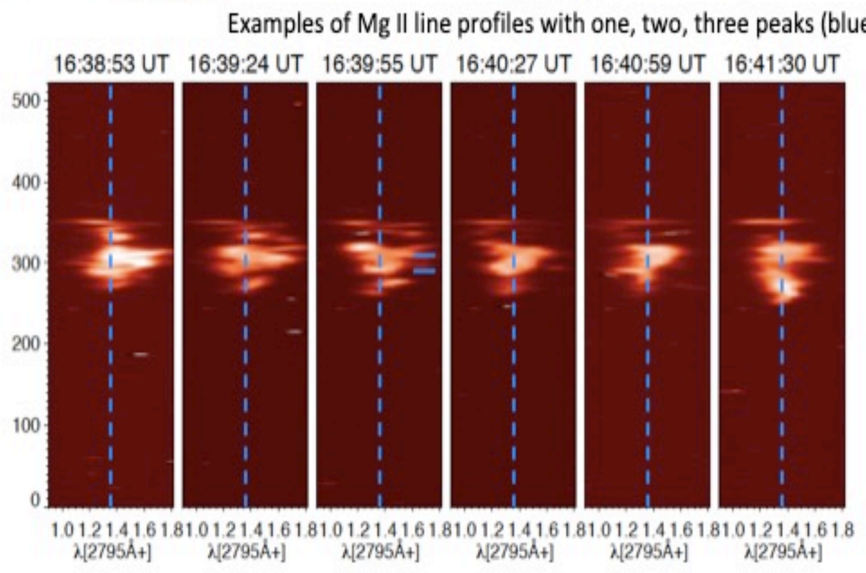
IRIS- MSDP/Meudon Hα- AIA



Top panels: IRIS slit jaw, Hα center, Hα high contrast
Low panels: AIA 304, Mg II SJI, AIA 171, AIA193,
Prominence (bright area is where R-RMS gives good fitting)



Examples of Mg II line profiles with one, two, three peaks (blue dashed line is the rest lambda)



IRIS Mg II k spectra in the top of the prominence (tornado) along 6 slits (blue dashed line is the rest lambda). Shifts on the left/right indicate blue/red shift. Rotation is suggested.

Results

(Peat et al 2021, Barcynski et al 2021,Labrosse et al 2022, Heinzel et al 2022)

Mg II IRIS profiles have been fitted with the R-RMS method. From the non LTE radiative codes the synthetic profiles allow to define

- the electron density (large range of values 10^9 to 10^{11}cm^{-3})
- the temperature (20000 K in the tornado)
- the optical thickness for Mg II k (around 60)

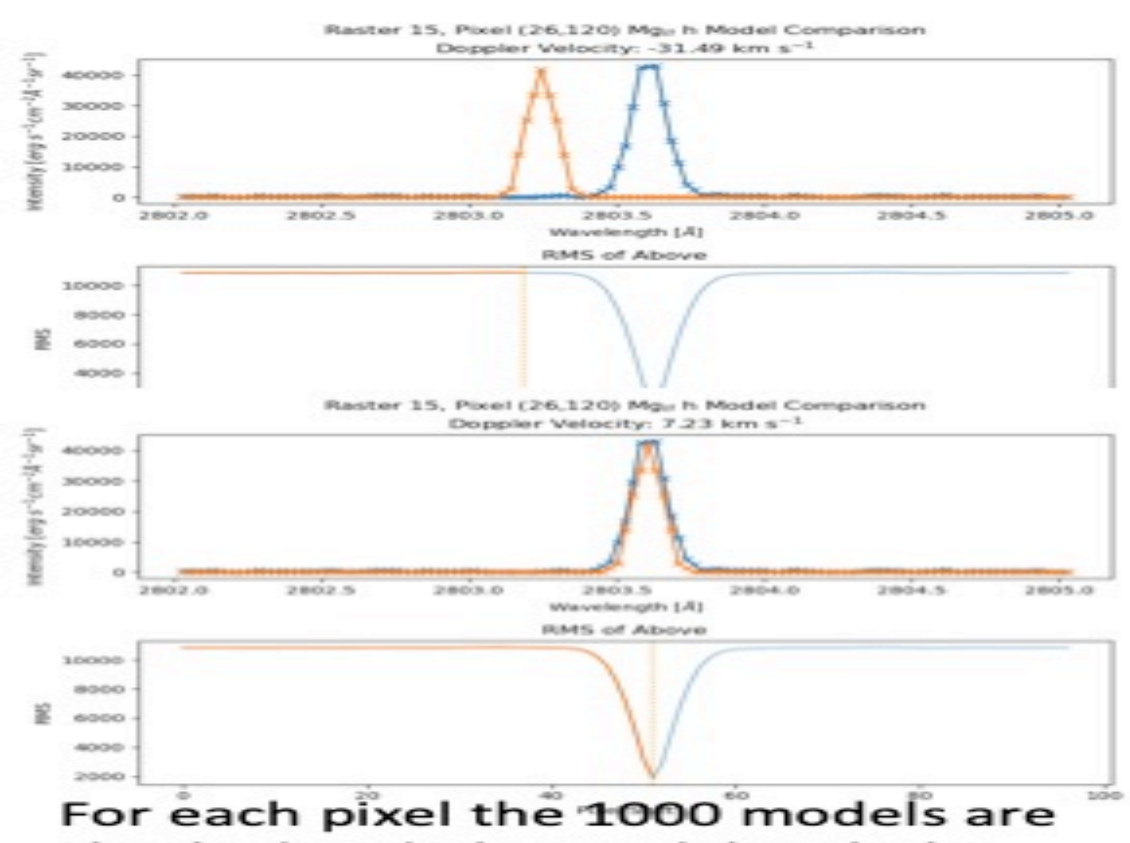
NLTE radiative transfer codes

1 D model of radiative transfer (Heinzel and Anzer 2001 , Gouttebroze, 2004,2007, Levens & Labrosse 2019)

For Mg II and Hα simultaneously (IRIS and MSDP and THEMIS)

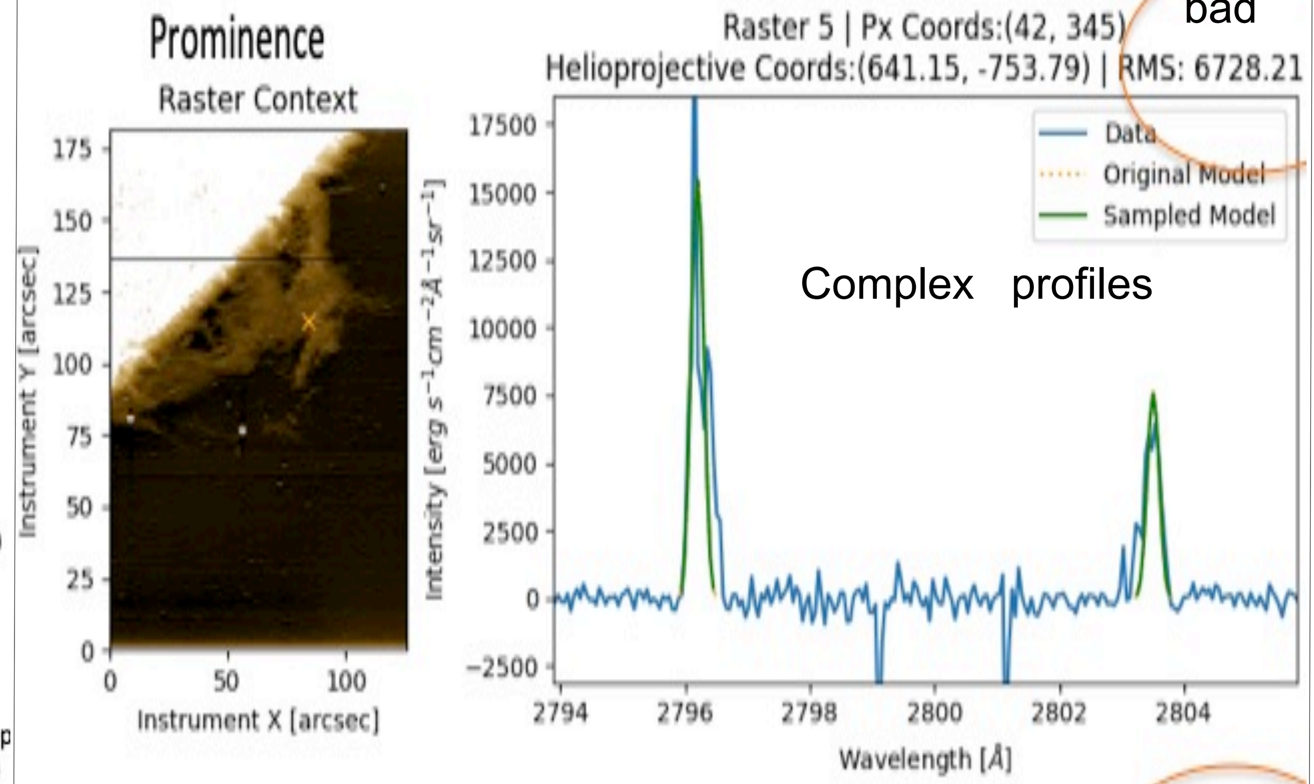
1. With physical parameters: integrated Intensity (I_{int}) and FWHM of one line construction of 1000 models isothermal, isobaric (Jejcic et al 2018, Ruan et al 2018, 2019)
2. Construction of 63 000 models with **5 parameters:** (I_{int}) and FWHM in both lines , Mg II k/h, (Jejcic et al 2022)
3. With **a new method: « rolling Root Mean Square R- RMS »** to fit the full profile using 1000 models (Peat et al 2021),
4. With **a new method « X-RMS «** (crossing) using cross-correlation defining 23940 models Including models with PCTR and models isothermal (Peat et al in prep.)

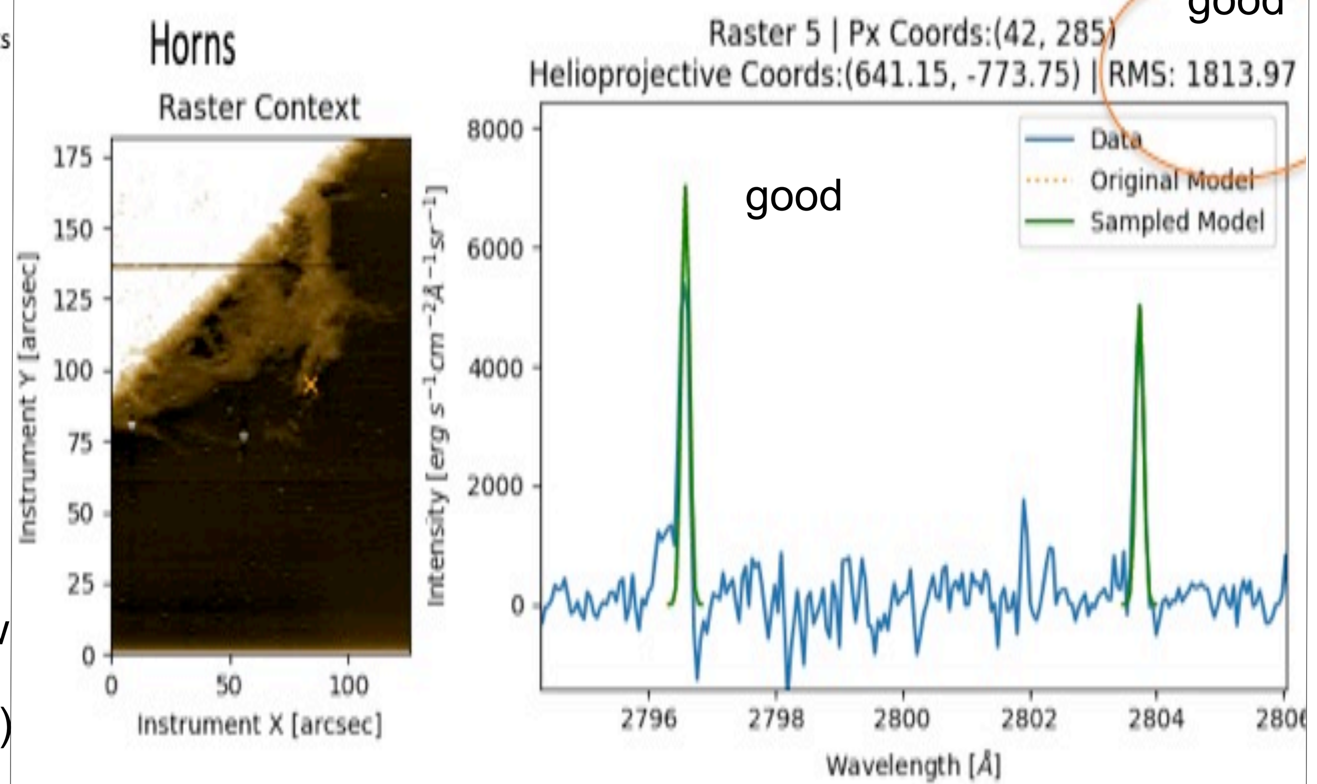
R-RMS method



For each pixel the 1000 models are checked and the model with the smallest RMS value is the best

X- RMS Fitting examples



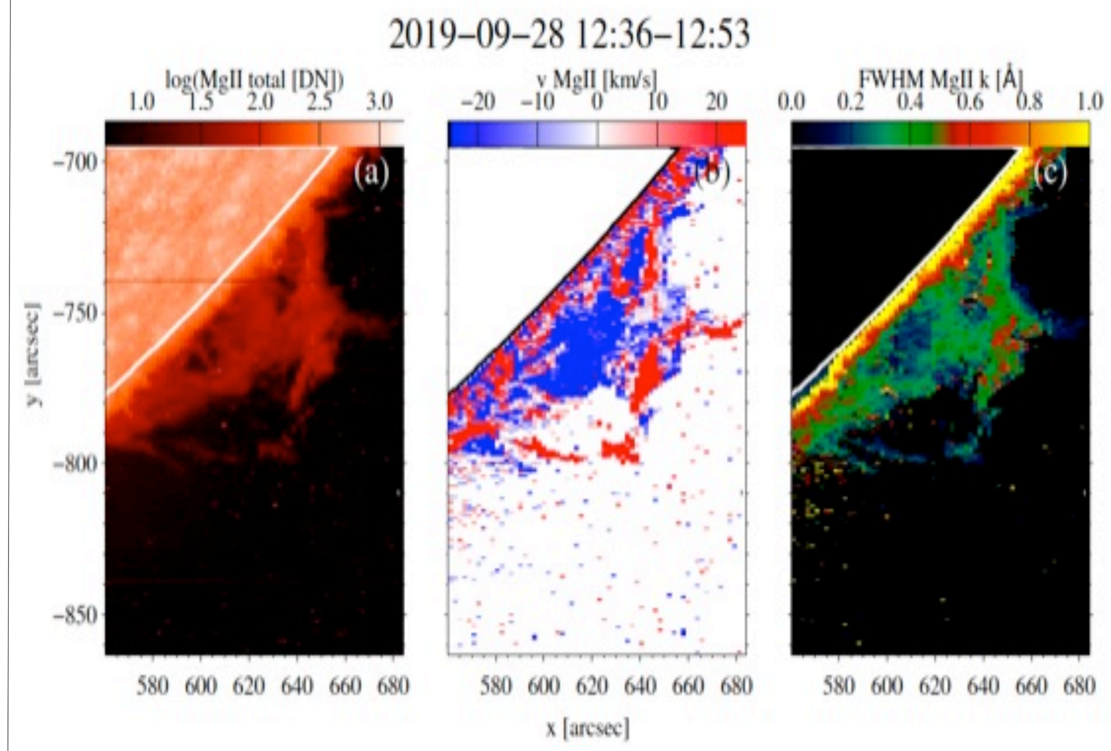


Each profile is tested with the 23940 models.
For the best value of RMS of the cross correlation the model is kept.

PROMINENCE with two horns

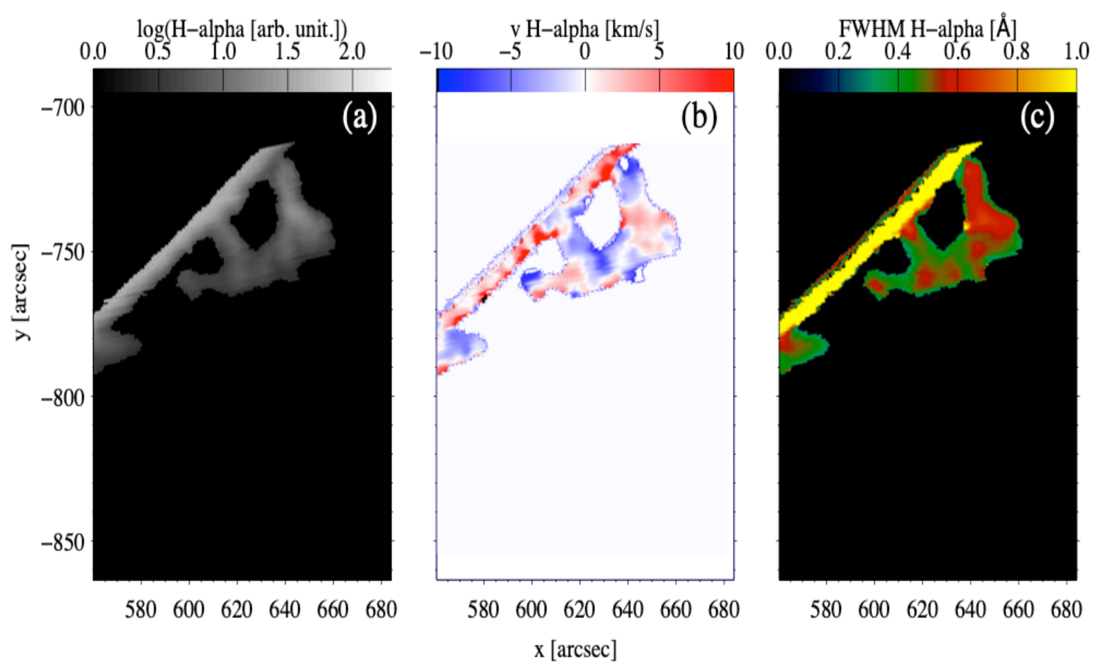
IRIS Observations and Dopplershifts

September, 28, 2019

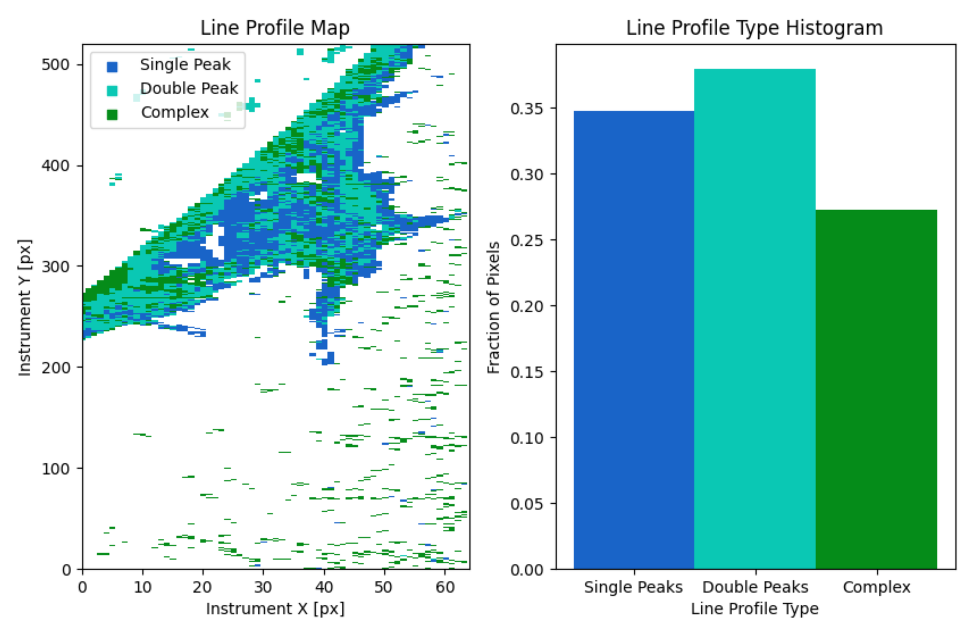


Mg II IRIS prominence: Intensity, Dopplershift, FWHM

THEMIS Observations



Hα prominence: Intensity, Dopplershift, FWHM (THEMIS) (Barczynski et al 2022)



Example of classification of the shape (with one or complex peak) of the IRIS Mg II k line profiles for raster 5 with the X-RMS method (Peat et al 2023)

Summary

- **We need to consider the PCTR for fitting Mg II profiles**
- **In the horns or top of the tornado T=10000-20000 K**
- **With ALMA and Hα from Bialkov we found that the core temperature of the prominence is 6000-8000K.**

References

Barczynski, Schmieder, Peat, Labrosse 2021 A&A 653, 94B
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